NON-MARINE MOLLUSCS FROM DOLOMITIC LIMESTONES IN THE NORTH OF SOUTH AUSTRALIA

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Summary

LUDBROOK, N. H. (1980) Non-marine molluscs from Miocene dolomitic limestones in the north of South Australia. *Trans. R. Soc. S. Aust.* **104**(4), 83-92, 30 May, 1980.

Non-marine molluscs, from the type section of the Etadunna Formation at Lake Palankarinna (KOPPERAMANNA 1:250 000 map sheet), and from dolomitic limestones on the BILLA KALINA and TARCOOLA 1:250 000 map sheets are described and correlated with those occurring in northern Australia. Etadunna Formation molluscs from Lake Palankarinna are land snails — *Bothriembryon praecursor* and *Meracomelon lloydi* — while those from near "Billa Kalina" and "Malbooma" and also from Lake Woorong on the COOBER PEDY 1:250 000 map sheet are freshwater species of *Syrioplanorbis*, *Physastra* and *Rivisessor*. The dolomitic limestones are considered to be of Miocene age.

Introduction

In describing fossil non-marine molluscs from northern Australia, McMichael (1968) cited some of the species as occurring also in the "Etadunna Formation, Billa Kalina Station, South Australia." Tabulating the localities, lithology and faunas of samples examined by McMichael, Lloyd (1968) similarly attributed to the Etadunna Formation, Tirari Desert, three species, two of which came from Lake Palankarinna and one from Billa Kalina. The present paper seeks to correct the unfortunate confusion of two widely separate localities, shown on Figure 1, and to distinguish between those molluscs which occur in the type section of the Etadunna Formation at Lake Palankarinna and those in the dolomitic limestones cropping out north of "Billa Kalina" Homestead. The fossil content of dolomitic limestones from near "Malbooma O.S." is also placed on record.

All the material studied is in the Palaeontological Collection of the Geological Survey of South Australia. All map references are to the Geological Atlas Series.

Specimens from both Lake Palankarinna and north of "Billa Kalina" were sent to McMichael at the Australian Museum in 1963 with references to published data on the Etadunna Formation and a note to the effect that "the dolomite containing *Planorbis* from Billa Kalina is not necessarily to be correlated with the Etadunna." In official correspondence, McMichael tentatively identified the Etadunna gastropods respectively as belonging to the genus *Bothriembryon* and similar to land snails of the genera *Meracomelon* and *Sinumelon*, probably the former, and the material from Billa Kalina as a large *Planorbis*-like shell.

In 1965, Etadunna specimens were again sent to McMichael to supplement his studies of the northern Australian fauna. No material from Billa Kalina was included. McMichael's (1968) reference to the occurrence of certain species in the "Etadunna Formation, Billa Kalina Station" seems to originate in notes he made in 1963 when he had specimens from both localities.

One of the unfortunate consequences of the error is that the gastropods of the type section of the Etadunna Formation at Lake Palankarinna have been only obscurely recorded. Moreover, the molluscs from the Etadunna Formation are land snails, while those from Billa Kalina are freshwater. The only limestones containing both land and freshwater molluscs (tabulated by Lloyd 1968) appear to be in the Deep Well area of Central Australia and the Carl Creek Limestone of the Riversleigh area, Queensland.

Molluscs from the Etadunna Formation

The molluscs from Lake Palankarinna, south of Cooper Creek, 23 km SW of "Etadunna" (lat. 28°48'S, long. 138°25'E, locality sample number 6540 RS 59, KOPPERAMANNA 1:250 000 map sheet) were collected by R. H. Tedford from nodular dolomitic limestone at the base of member 2e, Etadunna Formation (Stirton *et al.* 1961). Additional specimens were collected by J. M. Lindsay in 1970. They therefore come from low in the formation, some 5 m above the base, although gastropods have been recorded by Stirton and his col-

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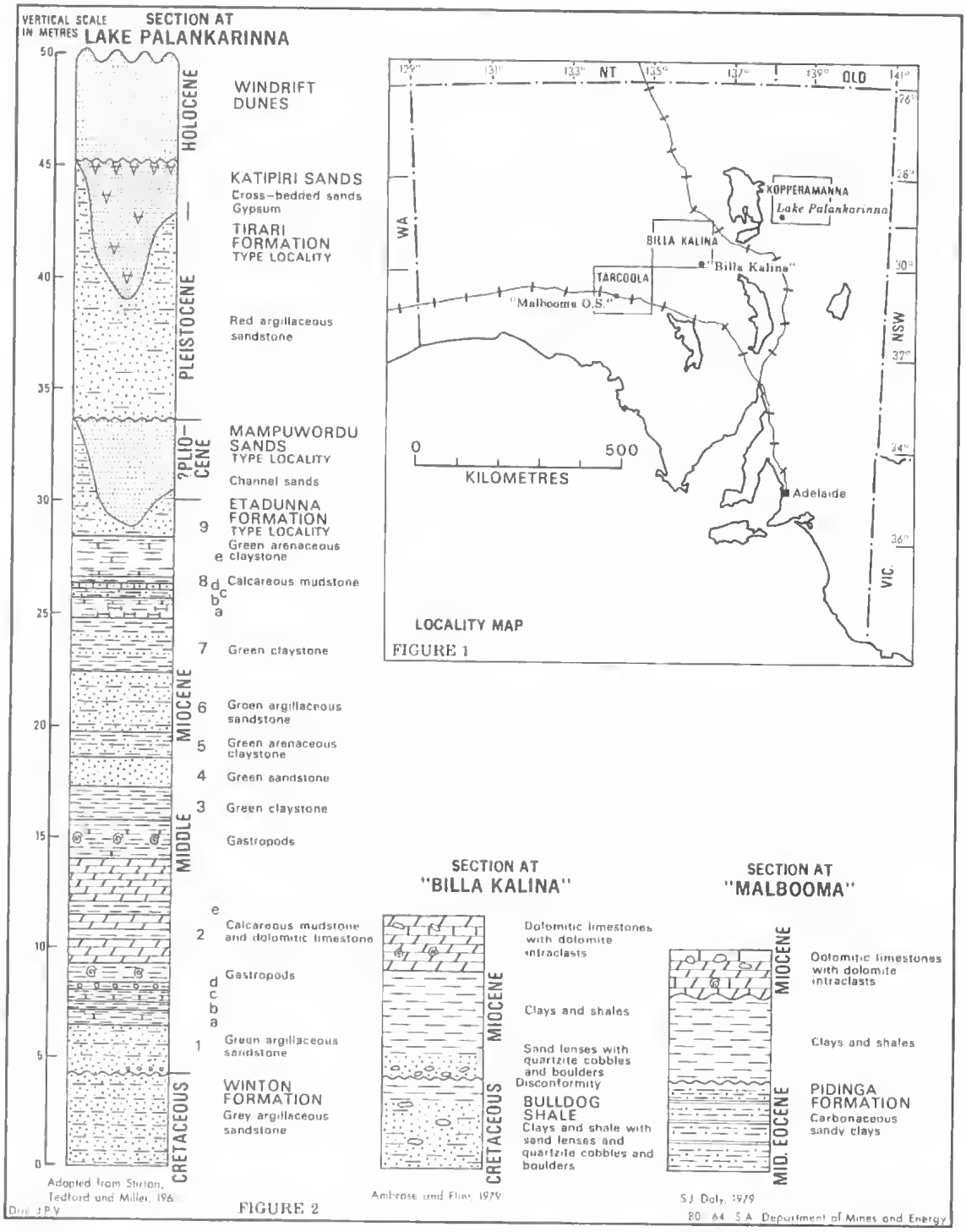

VERTICAL SCALE IN METRES
SECTION AT LAKE PALANKARINNA
HOLOCENE
WINDRIFT DUNES
KATIPIRI SANDS
Cross-bedded sands
Gypsum
TIRARI FORMATION
TYPE LOCALITY
PLEISTOCENE
Red argillaceous sandstone
?PLIO-CENE
MAMPUWORDU SANDS
TYPE LOCALITY
Channel sands
ETADUNNA FORMATION
TYPE LOCALITY
9
e Green arenaceous claystone
8 d c b a Calcareous mudstone
7 Green claystone
MIOCENE
6 Green argillaceous sandstone
5 Green arenaceous claystone
4 Green sandstone
3 Green claystone
MIDDLE
Gastropods
e
2 Calcareous mudstone and dolomitic limestone
d c b a Gastropods
1 Green argillaceous sandstone
CRETACEOUS
WINTON FORMATION
Grey argillaceous sandstone
50
45
40
35
30
25
20
15
10
5
0
Adopted from Shirley, Tedford and Miller, 196
NT
QLD
WA
NSW
VIC
KOPPERAMANNA
Lake Palankarinna
BILLA KALINA
"Billa Kalina"
TARCOOLA
"Malbooma O.S."
Adelaide
0
500
KILOMETRES
LOCALITY MAP
FIGURE 1
SECTION AT "BILLA KALINA"
Dolomitic limestones with dolomite intraclasts
Clays and shales
Sand lenses with quartzite cobbles and boulders
Disconformity
BULLDOG SHALE
Clays and shale with sand lenses and quartzite cobbles and boulders
MIOCENE
CRETACEOUS
Ambrose and Flint, 1979
SECTION AT "MALBOOMA"
MIOCENE
Oolomitic limestones with dolomite intraclasts
Clays and shales
PIDINGA FORMATION
Carbonaceous sandy clays
MID. EOCENE
S.J. Daly, 1979
80 64 S.A. Department of Mines and Energy
FIGURE 2

leagues from calcareous mudstones at both the base and top. The measured stratigraphic type section at Lake Palankarinna, redrawn after Stirton *et al.*, is shown in Figure 2.

In the opinion of Stirton *et al.* (1961), the sequence of dolomitic limestones, calcareous mudstones and claystones with intraformational breccias represents deposition in a shallow-water lagoon with repeated exposure and drying. The green claystones and argillaceous sandstones have yielded the important Ngapakaldi vertebrate fauna which contains lungfish and water birds. It includes also diprotodonts and macropodids which appear to have been entrapped in boggy clay. Gastropods in the dolomitic limestones are in the form of moulds and casts, many of which are freed from the matrix. They seem to be locally common and gregarious, but belong to only two species, *Bothriembryon praecursor* McMichael and *Meracomelon lloydi* McMichael. Both species are related to land snails typically inhabiting arid parts of the State — *Bothriembryon barretti* the Nullarbor Plain and *Meracomelon* spp. the Northern Flinders Ranges. As no freshwater shells have so far been found with them, they are presumed to represent the drying-out periods of deposition of the Etadunna Formation postulated by Stirton and his colleagues.

The possible relationships between land snails from non-marine deposits in and near Hobart and species of *Bothriembryon* and *Meracomelon* occurring in the Etadunna Formation were considered by McMichael. Examination of the limited amount of material now available from Hobart, discussed in the systematic section, has failed to establish similarity between the Tasmanian species in the Geilston Travertine and those from the Etadunna Formation.

Molluscs from the Billa Kalina area

The following description of the planorbid-bearing limestones from north of "Billa Kalina" Homestead (locality and sample numbers 6138 RS 62-73, 87, BILLA KALINA 1:250 000 map sheet, lat. 29°53′S, long. 136°11′E) is modified from Ambrose & Flint (1979)[1].

Tertiary sediments near "Billa Kalina" form a thin capping, maximum thickness 13 m, on shales and conglomeratic sands of Early Cretaceous Bulldog Shale. A resistant dolomitic limestone within the Tertiary sequence overlying the more-easily eroded shales results in flat-topped plateaux and mesas.

An idealised sequence (Fig. 2) comprises a very thin basal sand horizon containing quartzite clasts derived from erosion of the Cretaceous sediments. This is overlain by approximately 5 m of green dolomitic and occasionally palygorskite-bearing clays, which are in turn overlain by 1.5 m of white fossiliferous limestones and dolomitic limestones.

Samples with planorbids, to which the number 6138 RS 87 has been assigned, were first collected from these limestones in 1958 by H. G. Roberts during reconnaissance mapping for Clarence River Oil Syndicate. Subsequent collections (6138 RS 62-73, containing hydrobiids) were made in 1979 by G. J. Ambrose and R. B. Flint during mapping of the BILLA KALINA 1:250 000 map sheet from three localities within a distance of 1.5 km from 3.5-4.0 km NNW to N of "Billa Kalina". The total amount of material is not large, and the known fauna is limited to four species—an undescribed species of *Rivisessor* occurring in samples 6138 RS 62-73, *Syrioplanorbis hardmani*, *Syrioplanorbis* sp., and *Physastra rodingae*, either in crowded masses or scattered throughout the matrix. These were freshwater inhabitants of or were washed into the Tertiary lake postulated by Ambrose and Flint.

The Tertiary sediments on Billa Kalina and Millers Creek Stations have been correlated, on a lithological basis, with the Etadunna Formation of the Lake Eyre Basin and the Namba Formation of the Tarkarooloo Basin (Jessup & Norris 1971; Ambrose & Flint 1979[1]). Jessup & Norris divided what they considered to be the Etadunna Formation in the Billa Kalina-Millers Creek area into two members — a lower Billa Kalina Clay Member and an upper Millers Creek Dolomite Member. A revision of this nomenclature is presently being prepared by Ambrose and Flint, and, pending its publication, the Billa Kalina Clay Member and the Millers Creek Dolomite Member are here regarded as units of an unnamed formation. The molluscs in the dolomites provide the only direct evidence so far obtained for correlating them with other formations of known Tertiary age.

[1] Ambrose, G. J. & Flint, R. B. (1979). A regressive Tertiary lake system and silicified strand lines, Billa Kalina area, South Australia. S.A. Dept. Mines & Energy Rept 79/104 (unpublished).

Material from "Malbooma Outstation" area

Tertiary fossils were first collected in this area in 1979 by R. B. Flint, S. J. Daly and A. F. Crooks (locality and sample numbers 5736 RS 47-52 TARCOOLA 1:250 000 map sheet, lat. 30°39'S, long. 134°05'E). A brief geological description is provided by S. J. Daly: "Possible late Tertiary sediments west of "Malbooma O.S." crop out poorly, and form low rises which are veneered by calcrete. The best exposures are in railway cuttings on the Trans Australia Railway Line. The sequence, thought to be approximately 6 m thick, overlies carbonaceous sandy clays and sands of the Middle Eocene Pidinga Formation" (Fig. 2).

In a railway cutting 15.5 km west of "Malbooma O.S.", dark olive-green clays with red and yellow mottling are overlain by white-yellow fossiliferous dolomitic limestones which are fragmental at the top. The base of the sequence is not exposed. No fossils were previously known in the sequence".

The limestones are sparsely fossiliferous with scattered impressions, fragments and casts of *Rivisessor* sp. in a pelletal matrix. Occasional oogonia of a charophyte are also present. The environment was lacustrine, probably similar to and contemporaneous with that at "Billa Kalina".

Dolomitic limestone from Lake Woorong

In March 1980, fossiliferous dolomitic limestone (sample 5739 RS 23) was collected by M. C. Benbow, G. W. Krieg and P. A. Rogers from the southern lake of Lake Woorong, 32 km west of Lake Phillipson (lat. 29°36'06"S, long. 134°07'54"E, COOBER PEDY 1:250 000 geological map sheet). The hard dolomitic limestone, with dolomite clasts and occasional scattered casts and moulds of small gastropods, is similar to material collected from near "Billa Kalina". Although preservation is very poor, by analogy with the Billa Kalina and Malbooma material, the casts and moulds can be identified as the freshwater gastropods *Rivisessor* sp. and *Physastra rodingae*. The material was collected too recently for the locality to be included in either Figure 1 or Figure 2. COOBER PEDY adjoins TARCOOLA on the south and BILLA KALINA on the east.

Age and correlation of the dolomitic limestones

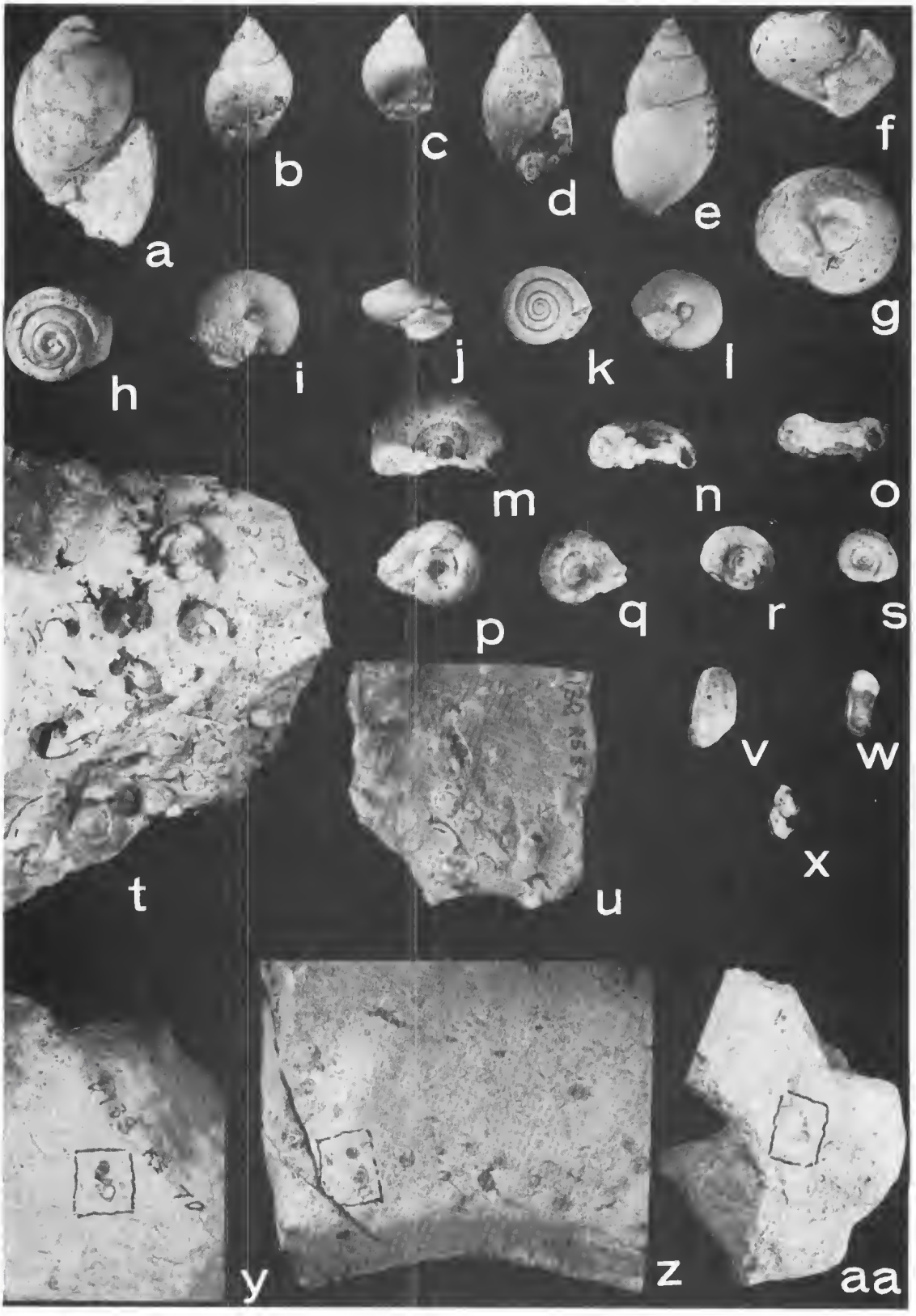
The age of the Etadunna Formation has been determined by W. K. Harris on unpublished palynological data as Middle Miocene (Callen & Tedford 1976, Callen 1977). The Etadunna land molluscs *Bothriembryon praecursor* and *Meracomelon lloydi* occur, either separately or together, in unnamed Tertiary limestones near "Deep Well" SSE of Alice Springs and in the Carl Creek Limestone N and SE of "Riversleigh," Queensland.

The molluscs in the limestones in the Billa Kalina, Malbooma and Lake Woorong areas are from a freshwater environment and do not provide direct correlation with the Etadunna Formation. They are related to one another by the presence of *Rivisessor* sp. The small assemblage of *Syrioplanorbis hardmani* and *Physastra rodingae* permits correlation of the dolomites near "Billa Kalina" with the White Mountain Formation of the Ord Basin in northwestern Australia, the Arltunga Beds, unnamed limestones of the "Deep Well" area, in the Alice Springs area, and the Carl Creek Limestone, Horse Creek Formation and Brunette Limestone in Queensland. All of these have been regarded by Lloyd (1968) as of Miocene age but not necessarily correlates. The limestones at Billa Kalina and Malbooma are therefore considered to be also of Miocene age, but not necessarily exact correlates of the lower part of the Etadunna Formation.

Systematic descriptions

Class GASTROPODA
Subclass PROSOBRANCHIA
Order MONOTOCARDIA

Fig. 3 (a-e) *Bothriembryon praecursor*, Etadunna Formation, Lake Palankarinna. (a) M2738(1) x 1.2, large specimen. (b, c) M2738(3), showing faint internal spiral ribbing. (d, e) M2744(3), narrow specimen with axial ribs. a x 1.2. (f-l) *Meracomelon lloydi*, Etadunna Formation, Lake Palankarinna. (f) M2740, apertural view. (g) M2740, umbilical view. (h) M2741(1), apical view. (i) M2741(1), umbilical view. (j) M2743, apertural view. (k) M2743, apertural view. (l) M2743, umbilical view. (m-u) *Syrioplanorbis hardmani*, Billa Kalina (m-o.) M2746(1), broken specimen giving natural section showing asymmetrical aperture. (p, q) M2746(2) lower and upper sides. (r, s) M2746(3) lower and upper sides. (t) M3579(1), (u) M3579(3) moulds and casts in limestone. (v, w) *Syrioplanorbis* sp., Billa Kalina (v) M3580(1), showing spiral ribbing. (w) M3580(2), showing symmetrical aperture. (x) *Physastra rodingae*, Billa Kalina, M3581(1). (y, z, aa) *Rivisessor* specimens in matrix. (y) 6138 RS 70, Billa Kalina. (z) 6138 RS 71, Billa Kalina. (aa) 5736 RS 48, Malbooma.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Suborder TAENIOGLOSSA = MESOGASTROPODA
Superfamily RISSOACEA
Family HYDROBIIDAE
Genus RIVISESSOR Iredale, 1943

Rivisessor sp.

FIGS 3y, z, aa

Material: Numerous specimens scattered throughout the matrix of samples 6138 RS 62-67 from 4 km NNW of "Billa Kalina", 6138 RS 68-70 from 3.5 km N of "Billa Kalina" and 6138 RS 71-73 from 4 km N of "Billa Kalina", casts and moulds in matrix of samples 5736 RS 47-51 15.5 km W of "Malbooma O.S." and 5736 RS 52 9 km W of "Malbooma O.S."

Description: Shell small, smooth, thiek, solid, whorls 4 to 5, moderately tumid, suture impressed. Aperture oval, entire, oblique; last whorl 3/5 height of shell. Height 5, diameter 2.5, height of last whorl 3, height of aperture 1.5 mm. Maximum height estimated from an imperfect natural section 7, diameter 3 mm.

Distribution: Limestone cappings at Billa Kalina, localities 6138 RS 62-73 (BILLA KALINA 1:250 000 map sheet) and Malbooma, localities 5736 RS 47-52 (TARCOOLA 1:250 000 map sheet).

Habitat: Living species of *Rivisessor* commonly inhabit streams, lagoons and ponds.

Order BASOMMATOPHORA
Superfamily LYMNAEACEA
Family PLANORBIDAE
Genus SYRIOPLANORBIS Baker, 1945

Syrioplanorbis hardmani (Wade)

FIG 3 m-u

Planorbis hardmani McCoy. Hardman 1885: 7, 15 (nom. nud.)
Planorbis hardmani (Foord) (sic) Wade, 1924: 29, pl. 1
Planorbis hardmani Wade. Chapman 1937: 61, pl. 6, figs 1, 2
Syrioplanorbis hardmani (Wade). McMichael 1968: 141, pl. 10, figs 6-8

Material: 15 internal casts GSSA M2746; numerous internal casts and moulds in matrix, M3579 (locality 6138 RS 87, 4 km N of "Billa Kalina").

The species was described adequately by McMichael. All specimens show the slight asymmetry with a deeply concave upper surface and shallowly concave lower surface typical of the species. Dimensions of the ten measurable specimens are consistent with those of the types from White Mountain Hills, Western Australia and specimens from south of Herrmansburg in Central Australia:

GSSA Reg. No.	*Diam. (mm)*	*Height (mm)*	*Diam./Height ratio*
M2746(1)	20.0	7.4	2.70:1
M2746(2)	18.0	7.0	2.57:1
M2746(3)	16.4	5.4	3.04:1
M2746(4)	11.4	5.0	2.28:1
M2746(5)	13.7	6.0	2.28:1
M2746(6)	12.0	5.5	2.18:1
M2746(7)	12.4	5.4	2.30:1
M2746(8)	11.9	6.0	1.98:1
M2746(9)	11.4	5.5	2.07:1
M2746(10)	9.6	4.5	2.13:1
Average	13.68	5.77	2.37:1

Type locality: Trig J40, 15 km E of N of "New Ord River", White Mountain Hills, lat. 17°15′37″S, long. 128°57′57″E, LISSADELL 1:250 000 map sheet, Kimberley District, W.A. White Mountain Formation, ?Mioeene.

Distribution: The localities cited by McMichael are here reinterpreted from Lloyd (1968), Wells *et al.* (1970) and Playford *et al.* (1975): Western Australia-White Mountain Formation, White Mountain Hills 15 km E of N of "New Ord River", LISSADELL 1:250 000 map sheet; Northern Territory—NT 406, unnamed formation, 6 km W of Running Waters, 42 km S of Herrmansburg, HENBURY 1:250 000 map sheet; NT 409, unnamed formation, 16 km NNE of "Deep Well", 61 km SSE of Alice Springs, RODINGA 1:250 000 map sheet; NT 417, unnamed formation, 16 km NE of Undoolya Gap, 45 km E of Alice Springs, ALICE SPRINGS 1:250 000 map sheet; NT 422, Arltunga Beds, 3.2 km SW of Arltunga airstrip, ALICE SPRINGS 1:250 000 map sheet; NT 423, Arltunga Beds, Arltunga airstrip, ALICE SPRINGS 1:250 000 map sheet; AS 234, unnamed formation, 24 km SE of "Todd River" H.S., ALICE SPRINGS 1:250 000 map sheet; AS 235, unnamed formation, 21 km ESE of "Todd River" H.S., ALICE SPRINGS 1:250 000 map sheet; Queensland — Q9, Horse Creek Formation, 25.6 km SE of "Springvale" H.S., SPRINGVALE 1:250 000 map sheet; BT 169, Brunette Limestone, 45.6 km N of "Rockhampton Downs" H.S., ROBINSON RIVER 1:250 000 map sheet; South Australia — 6138 RS 87, unnamed formation, 4 km N of "Billa Kalina", BILLA KALINA 1:250 000 map sheet.

The genus is recorded from the Late Oligocene of Europe and the Far East, but as living only in Lebanon and Syria. No living representatives are known from Australia.

Habitat: Freshwater.

Syrioplanorbis sp.

FIGS 3v, w

Material: Two internal casts GSSA M3580(1-2), locality 6138 RS 87, 4 km N of "Billa Kalina" H.S.

Description: Sinistral, discoidal, both upper and lower surfaces deeply and fairly broadly umbilicate. Whorls 4½, regularly increasing, laterally somewhat compressed and inclined to be angulate at upper and lower curvature. Sutures deeply impressed. Shell unknown, but cast showing three conspicuous spiral ribs on lateral surface. Aperture more or less symmetrical, moderately arched.

GSSA Reg. No.	*Diam. (mm)*	*Height (mm)*	*Diam./Height ratio*
M3580(1)	12.2	6.3	1.94:1
M3580(2)	10.2	5.0	2.04:1
Average	11.2	5.6	2.0:1

Observations: Two specimens, although not well preserved, appear to differ from *Syrioplanorbis hardmani* in having laterally compressed whorls, which makes the shell relatively higher than *S. hardmani*, with an average diameter: height ratio of 2.0:1 in contrast with 2.37:1 average of ten specimens of *S. hardmani*. It is not known whether the three spiral ribs visible on the internal cast persist as external features.

There are not sufficient specimens, nor are they well enough preserved, to warrant a new specific name.

Distribution: Locality 6138 RS 87, 4 km N of "Billa Kalina", BILLA KALINA 1:250 000 map sheet.

Habitat: Freshwater.

Genus PHYSASTRA Tapparone-Canefri, 1883

Physastra rodingae McMichael

FIG. 3x

Isidora, near *I. pectorosa*, Etheridge in Cameron 1901: 14

Bullinus sp. nov. Chapman 1937: 63

Isodora (sic), Whitehouse 1940:24

Physastra rodingae McMichael, 1968: 146, pl. 11, figs 2-5

Material: Four poorly-preserved casts and moulds, mostly embedded in hard limestone, GSSA M3581 (1-4), locality 6238 RS 87, 4 km N of "Billa Kalina". They appear to be casts and external moulds of juveniles, with about 3 whorls, of the sinistral species which has 4-5 whorls in the adult.

M3581(1), an internal cast freed from the matrix, has dimensions: height 9.0, diameter 5.3 mm, compared with a height 33.0+, diameter 14.5 mm in the largest paratype.

Type locality: NT 407, 12 km NE of "Deep Well", 66 km SSE of Alice Springs, RODINGA 1:250 000 map sheet, unnamed formation.

Distribution: Western Australia-White Mountain Hills, White Mountain Formation, 15 km E of N of "New Ord River", LISSADELL 1:250 000 map sheet; Northern Territory — NT 407, unnamed formation, 12 km NE of "Deep Well", RODINGA 1:250 000 map sheet; NT 424, Waite Formation, 6.4 km S of "Alcoota" H.S., ALCOOTA 1:250 000 map sheet; Queensland—Q11, Carl Creek Limestone, 8 km N of "Riversleigh" H.S., locality 103 on LAWN HILL 1:125 000 map sheet; Q12, Carl Creek Limestone, 1.6 km SE of "Riversleigh" H.S., locality 90 on CAMOOWEAL 1:250 000 map sheet; South Australia — locality 6138 RS 87, unnamed formation, 4 km N of "Billa Kalina" H.S., BILLA KALINA 1:250 000 map sheet. The genus *Physastra* is recorded as living in Indonesia, Australia, New Zealand and New Caledonia.

Habitat: Freshwater.

Observation: McMichael included in the synonymy *Isidora*, near *I. pectorosa* identified by R. Etheridge jr, cited by Cameron (1901) and by Whitehouse (1940) as being abundant, often in crowded masses, in what is now known as the Carl Creek Limestone, which overlies Cambrian limestone near "Riversleigh" from which Lloyd's material also came. This synonymy is accepted in the absence of any material evidence to the contrary.

Order STYLOMMATOPHORA
Superfamily BULIMULACEA
Family BULIMULIDAE
Genus BOTHRIEMBRYON Pilsbry, 1894

Bothriembryon praecursor McMichael

FIGS 3 a-e

Bothriembryon praecursor McMichael, 1968: 149, pl. 11, figs 7-9

Material: 34 internal casts and several external moulds in matrix GSSA M2738 (1-5), M2739 (1-14), M2744 (1-3), M3582 (1-4), all from the type section, Etadunna Formation, dolomitic limestone member 2c, Lake Palankarinna, S. Aust. (locality 6540 RS 59, KOPPERAMANNA 1:250 000 map sheet).

The species is common in dolomitic limestone near the base of the Etadunna Forma-

tion and is here redescribed from internal casts of adult specimens collected from the type section.

Description: Shell not known, but from the appearance of the casts probably fairly thick, size moderate for the genus, elongate-turbiniform, with a moderately high spire and large last whorl; aperture about equal in height to spire; whorls 5, regularly increasing. Protoconch small but fairly high, of two whorls with tip immersed, adult whorls 3, slightly to moderately inflated, suture conspicuous, imbricating. Aperture subovate, outer lip gently arcuate, attached less than ½ way towards adapical suture, parietal lip probably concave, columellar lip nearly vertical, basal lip arcuate; umbilical chink present. Sculpture, as shown on internal cast, of axial folds or growth ridges fairly evenly spaced, about 17 on last whorl; in oblique light, some specimens appear to have 2 or 3 faint and shallow spiral grooves on last whorl, suggesting that there may be some spiral sculpture as well. Dimensions of largest specimen GSSA M2738(1) height 30.5, diameter 17.7 mm, ratio height: diameter 1.72:1, average of 23 specimens height 22.4, diameter 13.5 mm, ratio height: diameter 1.66:1. Two specimens M2738(2) and M2739(1) are conspicuously narrower than average, with dimensions — M2738(2) height 25.1, diameter 14.0 mm, ratio height: diameter 1.80:1, M2739(1) height 28.4, diameter 14.5 mm, ratio height: diameter 1.96:1.

Type locality: Rd 21, 6 km ENE of "Deep Well" H.S., RODINGA 1:250 000 map sheet, unnamed formation.

Distribution: Northern Territory — NT 409, unnamed formation, 16 km NNE of "Deep Well" H.S. 61 km SSE of Alice Springs, RODINGA 1:250 000 map sheet; Rd 21 unnamed formation, 6 km ENE of "Deep Well" H.S., RODINGA 1:250 000 map sheet; South Australia — locality 6540 RS 59, Etadunna Formation, Lake Palankarinna, south of Cooper Creek, KOPPERAMANNA 1:250 000 map sheet.

The pulmonate land snail *Bothriembryon* is restricted to Australia, mainly the south west, but there are representatives in Central Australia and Tasmania. *Bothriembryon barretti* Iredale is commonly found in great numbers under bushes in coastal areas of the Nullarbor Plain, where it survives under dry conditions.

Habitat: It is likely that *B. praecursor* lived in a similar environment.

Observations: McMichael (1968) distinguished between *B. praecursor* and the living *B. barretti*, and also the Tasmanian fossil species *B. gunnii* (Sowerby). The present study supports separating these species. The Pleistocene to Holocene *B. barretti* is a larger and narrower shell; of 173 specimens measured from Point Sinclair, South Australia (Ludbrook 1978), the largest was 39 mm high and 21 mm in diameter, and the average 31.5 mm high, 17.7 mm in diameter, ratio height: diameter 1.78:1.

Bothriembryon gunnii (Sowerby) has been referred to in the literature as follows:

Bulinus gunnii G. B. Sowerby, 1845, in Strzelecki: 298, pl. 19, fig. 6 (not fig. 5)

Bulimus gunnii Sowerby, Etheridge 1878: 177, Johnston 1880: 90, Johnston 1888: 283, pl. 34, fig. 7

Liparus gunni (unjustified emendation) G. B. Sby sp. Harris 1897: 3

The specific name has also been attached to a living Tasmanian species thought by some authors to be identical with it:

Bothriembryon gunnii var. *brachysoma* Pilsbry, 1900: 18, pl. 3, fig. 53

Bothriembryon gunni Sowerby, May 1921: 92; 1923: pl. 42, fig. 7

This is the species referred to in Iredale (1937: 313) and May revised Macpherson (1958, pl. 42, fig. 7) as *Tasmanembryon tasmanicus* Pfeiffer.

Bothriembryon gunni is now represented solely by the holotype in the British Museum (Natural History), an internal cast embedded in matrix aperture down, so that complete description is impossible. The specimen figured by Johnston (1888) cannot at present be found, and no other specimens are known. Johnston's figure is of an elongate-turbiniform shell with axial ribs and impressed sutures. Although both *Bulinus* and *Bulimus* have been widely used for genera in different families, it may be assumed that in replacing *Bulinus* (a sinistral shell, family Planorbidae) by *Bulimus* (= *Bulimulus*) Johnston implied the position of *Bulimus gunnii* in the Bulimulidae, as did also G. F. Harris in placing the holotype in *Liparus* (a synonym of *Bothriembryon*). Johnston's figure immediately invites comparison of *Bulimus gunnii* with *Tasmanembryon tasmanicum* (Pfeiffer), recorded as common on the east coast of Tasmania, near the sea on trees

and rocks, but the extreme paucity of material is a barrier to confirming the identity of the fossil.

Bulimus gunnii was described with *Helix tasmaniensis* from travertine limestone quarried near Hobart Town (Strzelecki 1845). There is some uncertainty whether this was the quarry visited by Darwin (Banks 1970) or that at Geilston Bay. Neither quarry is now accessible. That in Hobart was identified by Johnston and by Banks as at the western end of Burnett Street. Johnston's figured specimen, occurring also with *"Helix tasmaniensis"* came from the Geilston Travertine which was quarried at Geilston Bay on the northeast side of the River Derwent 3 km north of the Tasman Bridge. Johnston considered this to be the locality visited by Darwin and by Strzelecki. There seems to be no way of recollecting the material or of confirming that the holotype of *Bulinus gunnii* did in fact come from the Burnett Street quarry and not from Geilston Bay, but Geilston Bay seems the more likely locality. In describing the two quarries, McCormick (1847) stated that he found no traces of shells in the Hobart Town quarry, but *Helix* and *Bulimus* were embedded in the upper part of the indurated limestone quarried at Geilston Bay. Ten specimens of two species of *"Helix"* from Geilston Bay were kindly lent by the Geology Department of the University of Tasmania, but no specimens of *"Bulinus" gunnii* have been located. One of the specimens of *"Helix" tasmaniensis*, partly embedded in matrix, is extremely like Sowerby's holotype.

Direct comparison of *Bothriembryon praecursor* with *"Bulinus" gunnii* is therefore impossible at present. Moreover, the stratigraphic position of the limestone containing *"Bulinus" gunnii* and *"Helix" tasmaniensis* can be stated only as "Tertiary" from present knowledge. Strzelecki considered it to be of Pliocene age. A composite section of the Tertiary sediments at Geilston described by Johnston (1888) was modified by Tedford *et al.* (1975). Johnston recorded marsupial bones from yellow and brown mottled calcareous clay, which, according to Tedford *et al.*, is interbedded with the travertine. They compared a diprotodontid from the Geilston Travertine with *Ngapakaldia* from the Etadunna Formation, of Middle Miocene age. An apparent age of 22.4± 0.5 Ma was obtained for basalt overlying the travertine. A sample of carbonaceous sediments collected below basalt at Geilston Bay on the west side of the golf links was sent by the Tasmanian Museum to W. K. Harris, who has informed me verbally that "the age of the microflora is ?Pliocene-Pleistocene; it is not related to mid-Tertiary microfloras widespread in Tasmania".

It can only be said that dating of material from the sequence at Geilston Bay is confused, and any correlation with the Etadunna Formation based on molluscs out of the question. Neither *"Bulinus" gunnii* nor *"Helix" tasmaniensis* can be compared with known molluscs from the Etadunna Formation.

Superfamily HELICACEA
Family CAMAENIDAE
Genus MERACOMELON Iredale, 1937

Meracomelon lloydi McMichael

FIGS 3 f-l

Meracomelon lloydi McMichael, 1968: 151, pl. 11, figs 10-14

Material: Nine internal casts GSSA M2740-3, M3582 (1-2), one external mould.

The species was described by McMichael from internal casts and so far the Etadunna Formation has yielded only external moulds and internal casts. Etadunna specimens are generally smaller and higher than the holotype and paratypes from the Northern Territory and Queensland. They vary considerably in their relative height:

GSSA Reg. No.	*Diam. (mm)*	*Height (mm)*	*Diam./Height ratio*
M2740	22.0	17.8	1.24:1
M2741(1)	15.5	10.0	1.55:1
M2741(2)	12.0	6.4	1.87:1
M2742(1)	14.0	10.4	1.34:1
M2742(2)	13.5	8.6	1.57:1
M2742(3)	11.9	7.7	1.54:1
M2743	12.0	9.0	1.33:1
M3582(1)	13.5	8.7	1.55:1
M3582	13.3	7.0	1.90:1
Average of 9 specimens	14.2	9.5	1.49:1
Average of holotype and 5 paratypes	18.9	14.0	1.35:1

Type locality: NT 409, 16 km NNE of "Deep Well"; 61 km SSE of Alice Springs, RODINGA 1:250 000 map sheet, unnamed formation.

Distribution: Northern Territory — NT 409, 16 km NNE of "Deep Well", NT 407, 12 km NE of "Deep Well", NT 408, 1.6 km N of NT 407, and Rd 21, 6 km ENE of "Deep Well", all unnamed formation, RODINGA 1:250 000 map sheet; South Australia — locality 6450 RS 59, Etadunna Formation, Lake Palan-

karinna, south of Cooper Creek, KOPPERAMANNA 1:250 000 map sheet.

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